We claim:

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1. A thermodilution catheter apparatus, comprising:

a flexible tubular catheter member adapted for introduction into a blood vessel of a patient;

a flexible heating filament disposed with respect to said catheter member so as not to touch the patient's blood when said catheter member ~~is~~ inserted into a blood vessel, the heating filament applying a predetermined quantity of heat to blood in said blood vessel; and

temperature detecting means for detecting downstream temperature variations of said blood as a result of application of said predetermined quantity of heat to said blood.

2. An apparatus as in claim 1, wherein said heating filament is comprised of a material having a high temperature coefficient of resistance, whereby resistance of said heating filament is proportional or inversely proportional to its temperature.

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3. An apparatus as in claim 2, wherein power to said heating filament is reduced when resistance of said heating filament exceeds a predetermined resistance amount.

4. An apparatus as in claim 3, wherein said predetermined resistance amount is reached when the temperature of said heating filament reaches approximately 52°C.

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5. An apparatus as in claim 2, wherein the temperature coefficient of resistance of said heating filament is greater than 0.001 Ω/Ω-°C.

6. An apparatus as in claim 5, wherein said heating filament is comprised of approximately 70% nickel and 30% iron.

7. An apparatus as in claim 5, wherein said heating filament is comprised of approximately 29% nickel, 17% cobalt and 54% iron.

8. An apparatus as in claim 1, wherein said catheter member comprises a substantially cylindrical body wall portion and an outer sheath, said heating filament being wrapped in a thin layer about said body wall portion of said catheter member and enclosed by said sheath.

9. An apparatus as in claim 8, further comprising a layer of material with a high thermal conductivity disposed about said heating filament so as to create a more uniform surface temperature.

10. An apparatus as in claim 8, wherein said body wall portion has a reduced diameter in a region where said heating filament is wrapped therearound such that the resulting total diameter in said region is approximately equal to the diameter of said body wall portion in other regions.

11. An apparatus as in claim 8, wherein said sheath is a flexible material formed by one of extrusion and blow molding.

12. An apparatus as in claim 8, wherein said sheath is a flexible material which shrinks to form-fit said heating filament and said body wall portion when a sufficient quantity of heat is applied thereto.

13. An apparatus as in claim 8, wherein said temperature detecting means comprises one of a thermistor and thermocouple approximate to a distal end of said catheter member and disposed distally with respect to said heating filament.

14. An apparatus as in claim 8, wherein said temperature detecting means comprises one of a thermistor ~~and~~ or thermocouple disposed proximally with respect to said heating filament.

15. An apparatus as in claim 14, wherein a distal end of said catheter member comprises a pigtail tip.

16. An apparatus as in claim 1, further comprising at least one set of electrical leads attached to said heating filament at a first end thereof so as to apply power to said heating filament.

17. An apparatus as in claim 16, wherein a second end of said set of electrical leads is connected to a cardiac output computer which applies an appropriate power signal to said electrical leads when said predetermined quantity of heat is to be applied to said blood.

18. An apparatus as in claim 1, wherein said catheter member has at least one lumen through which said heating filament is removably inserted.

19. An apparatus as in claim 18, wherein said heating filament is wrapped in a thin layer about a substantially cylindrical supporting member, said supporting member and thin layer having ~~a combined~~ outer diameter which is approximately equal to an inner diameter of said at least one lumen.

20. An apparatus as in claim 19, wherein said heating filament is approximately 5 to 10 centimeters in length and is disposed approximately 10 centimeters from said temperature detecting means during measurement.

21. An apparatus as in claim 1, further comprising calibrating means for calibrating both said heating filament and said temperature detecting means.

22. An apparatus as in claim 21, wherein said calibrating means comprises a memory contained at a proximal end of said catheter member for storing calibration information for either said heating filament or both said heating filament and said temperature detecting means.

23. An apparatus as in claim 22, wherein said calibration information includes heating filament resistance at a given temperature, heating filament heat transfer efficiency, temperature coefficient of resistance and thermistor or thermocouple information.

24. An apparatus as in claim 22, wherein said memory is connected to a cardiac output computer and said memory further stores a program segment of a program used by said cardiac output computer to calculate cardiac output of said patient, whereby calculation of the patient's cardiac output cannot commence until said cardiac output computer is connected to said memory and said program segment is transferred to said cardiac output computer.

25. A thermodilution catheter apparatus, comprising:

a flexible tubular catheter member adapted for introduction into a blood vessel of a patient, said catheter member having at least one lumen;

a flexible heating filament removably insertable into said lumen of said catheter member for applying through said catheter member a predetermined quantity of heat to blood in said blood vessel; ~~and~~

temperature detecting means for detecting downstream temperature variations of said blood as a result of

application of said predetermined quantity of heat to said blood.

26. A thermodilution catheter apparatus, comprising:

a flexible tubular catheter member adapted for introduction into a blood vessel of a patient;

a flexible heating filament disposed with respect to said catheter member so as not to touch the patient's blood when said catheter member is inserted into a blood vessel, the heating filament applying a predetermined quantity of heat to blood in said blood vessel and being comprised of a material having a high temperature coefficient of resistance, resistance of said heating filament being proportional or inversely proportional to its temperature; and

temperature detecting means for detecting downstream temperature variations of said blood as a result of application of said predetermined quantity of heat to said blood.

27. An apparatus as in claim 26, wherein power to said heating filament is reduced when resistance of said heating filament exceeds a predetermined resistance amount.

28. An apparatus as in claim 27, wherein said predetermined resistance amount is reached when the temperature of said heating filament reaches approximately 52°C.

29. An apparatus as in claim 26, wherein the temperature coefficient of resistance of said heating filament is greater than 0.001 Ω/Ω-°C.

30. An apparatus as in claim 29, wherein said heating filament is comprised of approximately 70% nickel and 30% iron.

31. An apparatus as in claim 29, wherein said heating filament is comprised of approximately 29% nickel, 17% cobalt and 54% iron.

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32. A thermodilution catheter apparatus, comprising:

a flexible tubular catheter member adapted for introduction into a blood vessel of a patient;

a flexible heating filament wrapped in a thin layer about said catheter member and enclosed by a sheath so as not to be directly exposed to blood in said blood vessel, said heating filament applying through said sheath a predetermined quantity of heat to the blood in said blood vessel; and

temperature detecting means for detecting downstream temperature variations of said blood as a result of application of said predetermined quantity of heat to said blood.

33. A thermodilution catheter apparatus, comprising:

a flexible tubular catheter member adapted for introduction into a blood vessel of a patient;

a flexible heating filament disposed with respect to said catheter member so as not to touch the patient's blood when said catheter member is inserted into a blood vessel, the heating filament applying a predetermined quantity of heat to blood in said blood vessel;

temperature detecting means for detecting downstream temperature variations of said blood as a result of application of said predetermined quantity of heat to said blood; and

calibrating means for calibrating both said heating filament and said temperature detecting means, said calibrating means comprising a memory contained at a proximal end of said catheter member for storing calibration information for either said heating filament or both said heating filament and said temperature detecting means.

34. An apparatus as in claim 33, wherein said calibration information includes heating filament resistance at a given temperature, heating filament heat transfer efficiency, temperature coefficient of resistance and thermistor or thermocouple information.

35. An apparatus as in claim 33, wherein said memory is connected to a cardiac output computer and said memory further stores a program segment of a program used by said cardiac output computer to calculate cardiac output of said patient, whereby calculation of the patient's cardiac output cannot commence until said cardiac output computer is connected to said memory and said program segment is transferred to said cardiac output computer.

36. A method of applying heat to blood in a blood vessel of a patient for a thermodilution measurement, comprising the steps of:

inserting a flexible tubular catheter member into said blood vessel of said patient;

removably inserting a flexible heating filament through a lumen of said catheter member;

applying power to said heating filament so as to generate a predetermined quantity of heat; and

applying said predetermined quantity of heat through said catheter member to blood in said blood vessel.

37. A method as in claim 36, comprising the further steps of:

forming said heating filament of a material having a high temperature coefficient of resistance whereby resistance of said heating filament is proportional or inversely proportional to its temperature and having a low thermal capacitance and high thermal conductivity; and

reducing power to said heating filament when resistance of said heating filament exceeds a predetermined resistance amount.

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38. A method of applying heat to blood in a blood vessel of a patient for a thermodilution measurement, comprising the steps of:

inserting a flexible tubular catheter member having a heating element disposed beneath an outer sheath thereof into said blood vessel of said patient so as not to directly expose said heating element to blood in said blood vessel;

applying power to said heating element so as to generate a predetermined quantity of heat; and

applying said predetermined quantity of heat through said catheter member to blood in said blood vessel.

39. A method as in claim 38, comprising the further steps of:

forming said heating element of a material having a high temperature coefficient of resistance whereby resistance of said heating element is proportional or inversely proportional to its temperature and having a low thermal capacitance and high thermal conductivity; and

reducing power to said heating element when resistance of said heating element exceeds a predetermined resistance amount.

40. A method of thermodilution measurement, comprising the steps of:

inserting a flexible tubular catheter member into a blood vessel of a patient;

removably inserting a flexible heating filament through a lumen of said catheter member;

applying power to said heating filament so as to generate a predetermined quantity of heat;

applying said predetermined quantity of heat through said catheter member to blood in said blood vessel; and

detecting downstream temperature variations of said blood as a result of application of said predetermined quantity of heat to said blood.

41. A method as in claim 40, comprising the further step of calibrating said heating filament using a memory disposed at a proximal end of said catheter member, said memory storing calibration information including at least one of heating filament resistance at a given temperature, heating filament heat transfer efficiency, temperature coefficient of resistance and thermistor ~~or thermocouple~~ information.

42. A method as in claim 41, comprising the further steps of:

connecting said memory to a cardiac output computer; and

calculating cardiac output of said patient using said calibration information in said cardiac output computer.

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43. A method of thermodilution measurement, comprising the steps of:

inserting a flexible tubular catheter member having a flexible heating element disposed beneath an outer sheath thereof into a blood vessel of a patient so as not to directly expose said heating element to blood in said blood vessel;

applying power to said heating filament so as to generate a predetermined quantity of heat;

applying said predetermined quantity of heat through said catheter member to blood in said blood vessel; and

detecting downstream temperature variations of said blood as a result of application of said predetermined quantity of heat to said blood.

44. A method as in claim 43, comprising the further steps of:

storing in a memory disposed at a proximal end of said catheter member a program segment of a program used by

a cardiac output computer to calculate cardiac output of said patient;

connecting said memory to said cardiac output computer;

transferring said program segment to said program of said cardiac output computer; and

calculating the cardiac output of said patient in accordance with said program including said program segment and said detected temperature variations.

add B'

add D8

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